Space Weather Technical Forecast

Issued on Tuesday, 28 November 2023 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of isolated M-class flares. Chance of G1-G2 Minor/Moderate storms with CME arrival either late 29 Nov or early 30 Nov.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Activity has been Low, with a peak C6.7 flare at 27/1852 UTC from the vicinity of AR3500 in the southeast quadrant. This is the most notable region on the visible disc, with a weakening delta spot in the trailer portion of the region. There are eleven sunspots in total on the visible disc with a number of moderately sized but stable spots on the disc and a number of weak alpha spots. None of the spots are producing significant flare activity.

There are a number of filaments on the Earth-facing disc, with a broad eruption around 27/0535 UTC alongside a C3.3 flare. This produced a CME which is still under analysis, however a preliminary assessment suggests an Earth-directed component with arrival either late on 29 Nov or early on 30 Nov. A further eruption from the northeast quadrant around 27/1900 UTC will be analysed once sufficient imagery is available.

Solar Wind / Geomagnetic Activity: Solar wind speeds have been at slightly elevated winds speeds, around 450-500 km/s on a steady trend. Density has been around average. Interplanetary Magnetic Field (IMF), Bt, was weak with the north-south component, Bz also varying weakly. Phi angle was positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at background. GOES16 high energy (greater than 2MeV) electron flux has been at Background. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu). The observation at 28/0000 UTC was 2.4e6 integrated pfu.

Four-Day Space Weather Forecast Summary
Solar Activity: Solar activity is expected to be Low to Moderate, with a chance of isolated M-flares. AR3500 in the southeast quadrant is most likely to produce energetic flares.

Solar Wind / Geomagnetic Activity: A CME which left the Sun on 27 Nov is forecast to arrive at Earth either late on 29 Nov or early on 30 Nov, but with current low confidence. A further partial halo from the eastern hemisphere will be analysed once further data becomes available. A coronal hole high speed stream, from coronal hole 75 is expected to ease through 28 Nov with background levels then forecast in the absence of the CME effects. Quiet with Unsettled intervals through 28 Nov and into 29 Nov. Active to G1/Minor Storm intervals are then possible late on 29 Nov and into 30 Nov due to the potential CME arrivals. A gradual return back to Quiet to Unsettled conditions are then possible on 01 Dec.

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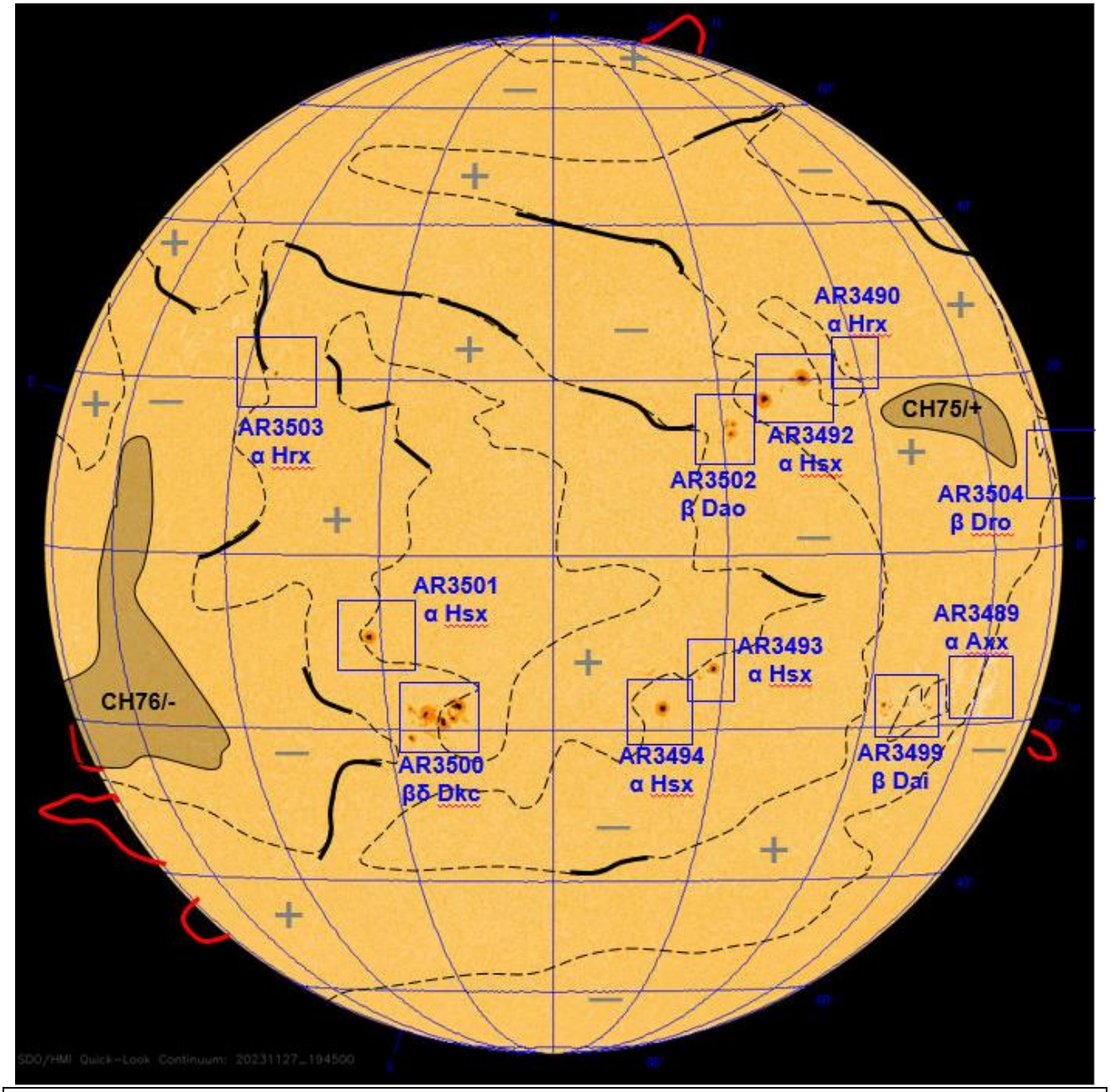
Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at background levels. There is a slight chance of flux towards or perhaps exceeding the S1 level given any significant flares from the active regions on the disc, or from any notable filament eruptions. Electron flux is currently at background, but perhaps trending towards moderate or high levels on diurnal peaks through 28 and 29 Nov. These levels may however be suppressed by the possible CME arrival. The associated fluence is expected to increase in response, but likely staying below the Active (1e8 integrated pfu) threshold, especially due to the possible effects of the CME.

Figure 1. Solar Analysis Valid 27/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is one CME in the forecast, which left the Sun early on 27 Nov and is initially forecast to arrive at Earth either late on 29 Nov or during 30 Nov. Analysis of recent imagery indicates that a partial halo has lifted from the Sun around 27/1900 UTC, with an eastern bias to the partial halo. The source is either a filament eruption from the northeast quadrant at around 27/1900 UTC, or from a C6.7 flare in the southeast quadrant close to AR3500. A full analysis will be undertaken once further imagery becomes available.

Solar wind speeds are currently slightly elevated, between 450-500 km/s, as the Earth remains under a relatively weak influence of coronal hole 75 in the northwest quadrant. This is a small feature, with winds likely to ease through the next 24 hours as the feature rotates towards the western limb. No further coronal holes are forecast to connect through the forecast period.

Quiet geomagnetic activity with isolated Unsettled intervals are forecast through 28 Nov and much of 29 Nov. The CME arrival is then forecast to affect Earth either late on 29 Nov or during 30 Nov, bringing a risk of Active to G1/Minor Storm intervals, with a slight chance of G2/Moderate Storms. Activity is then likely to ease on 30 Nov, subject to the possible arrival of the partial halo CME mentioned above.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	20	40	10
Strong	G3	No	1	5	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time	Comments
27/1135	Partial	Filament	SW	717	29/2300 UTC	Low confidence

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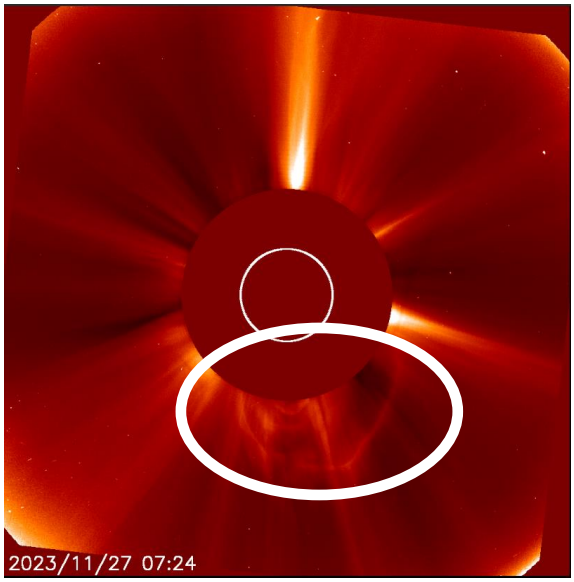
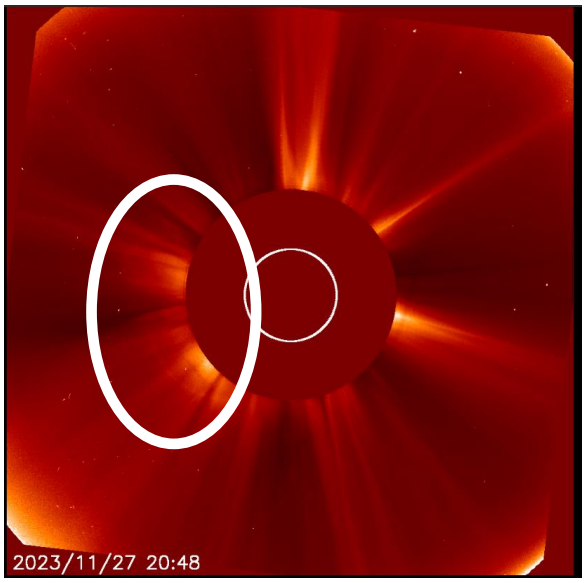
Figure 2: LASCO C2 imagery showing two CME eruptions. The latter eruption has not yet been analysed.





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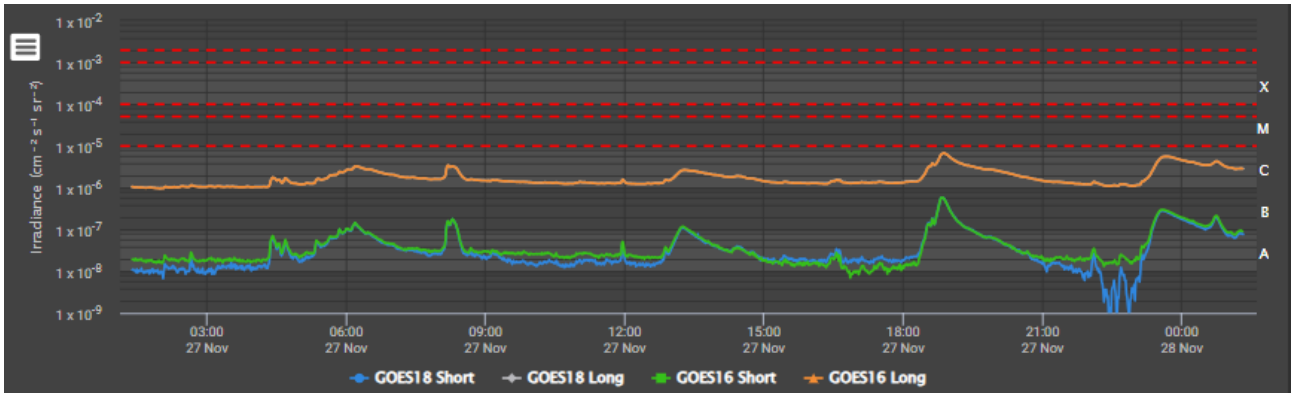
Radio Blackouts - X-Ray Flares:
Low to moderate activity is expected with eleven sunspot regions on the visible disc.
The most notable region is AR3500 which despite the complex nature has been relatively benign. This region did produced a C6.7 flare on 27 Nov which may have given rise to a CME, however further analysis will be required before confirming this. The region also contains a delta spot in the trailer region, but this appears to be weakening.

The remaining regions appear to be weak or only evolving slowly, with no significant flare activity.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	45	45	45	45
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16 X-ray flux



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at background. There are number of moderately sized sunspot regions on the disc, however the majority of these are magnetically simple mature spots with no significant activity. The main region of note is currently AR3500 in the southeast, which is both the largest region and maintains a weakening beta-delta configuration. There are also a number of filaments on the Earth-facing disc, and large eruptions, especially off the west disc, can result in proton flux increasing at Earth, albeit likely staying below the S1 Minor Radiation Storm level.

Overall this gives a slight chance of elevated protons through the period, with this risk increasing a little as AR3500 moves into the western disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is currently at background in the presence of a slightly elevated solar wind. As the solar wind speed eases through 28 Nov a slight increase in electron flux values is likely to moderate levels and increasingly to high levels on diurnal peaks. However any increases are subject to the possible CME arrival either late on 29 Nov or 30 Nov, which could lead to further drop outs.

Overall electron fluence is expected to remain below the Active threshold (1e8 integrated pfu), but with an upward trend possible through until later on 29 Nov. There is a little uncertainty later in the period due to the possible CME arrivals.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	10	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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